

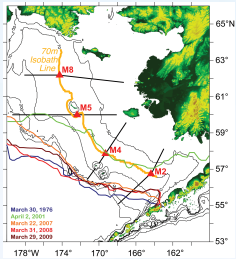
Bering Sea Biophysical Moorings

Understanding Ecosystems

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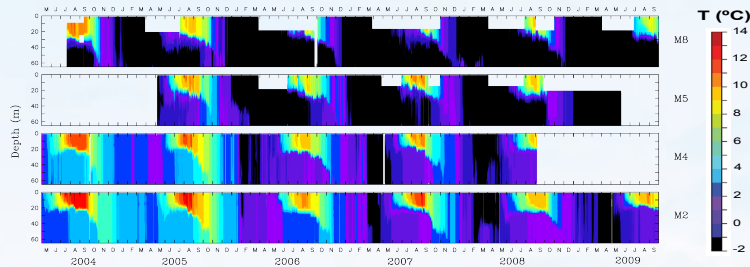
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Maximum Ice Extent



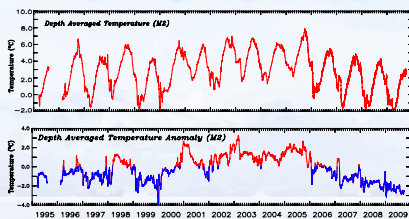
The network of moorings and hydrography. Maximum ice extent in warm and cold years are shown with dashed lines. Solid lines (black and gold) are hydrographic sections

Temperature at Mooring Sites

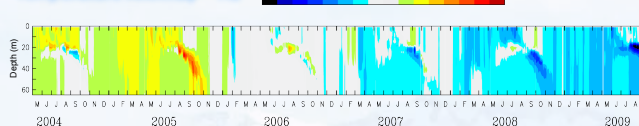


Temperatures measured at the four biophysical mooring sites, show a largely well-mixed water column during winter and a sharp two-layer structure during summer. The presence of sea ice over the shelf determines the ocean temperature during winter and spring, with extensive ice resulting in very cold (black) ocean temperatures.

Depth Averaged Temperatures (M2)

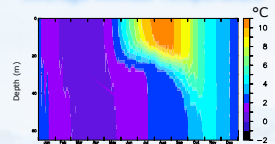


Temperature Anomaly - M2

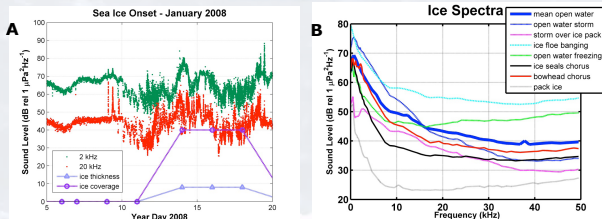


Depth-averaged temperatures (upper left) at M2 reveal the seasonal cycle. Subtracting the annual signal (1995-2008) shows the significant interannual variability (lower left). During years with extensive sea ice (e.g. 2007-2009), depth averaged temperatures are ~3°C colder than during years during which there was little or no sea-ice (e.g. 2001-2005) at M2. The average annual temperature structure is shown at the right. When the annual signal is subtracted from the temperature time series at M2 the structure of the temperature anomaly is shown (above). Note, 2005 was warm throughout the water column while 2008-09 was particularly cold. Interestingly, the temperature at M2 in 2006 was near average.

Average Annual Temperature

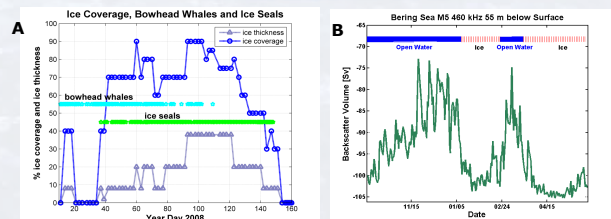


Underwater Sound



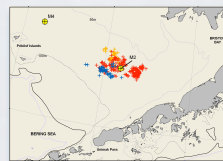
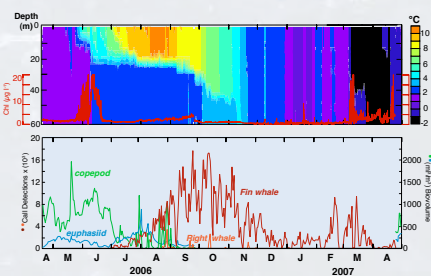
A) The onset of the ice cover (thickness in inches, coverage in %) is apparent in the acoustic record by a change in the temporal variability of the sound. As ice appears, the short time scale variability increases, at both low and high frequencies. The low frequency variability may be due to an increase in marine mammal calling, while the high frequency variability may be due to sound produced by different ice processes (freezing, melting, banging, etc.). B) Examples of spectra recorded under various ice conditions at M5. Very different and distinctive spectra are associated with different physical conditions, including times when marine mammals (bowhead whales, bearded & ribbon seals, and walrus) are present. As ice conditions change, the soundscape changes rapidly from one spectral type to another. Note the very distinctive spectrum associated with "open water freezing".

Mammals, Zooplankton and Ice



A) There is a strong correlation between the presence of marine mammals and sea ice. In particular, bowhead whales are present as the ice appears and stay until mid-April. Ice seals (mainly bearded and ribbon seals) and walrus are present (and vocalizing) only when the ice pack is present. These animals are not detected acoustically at this location during other times of the year. B) Time series of acoustic backscatter from near the seafloor obtained with a scientific echosounder (460 kHz). During a short period of ice retreat in late February 2009, the zooplankton community quickly responded at levels equal to seasonal maxima observed during the non-winter season.

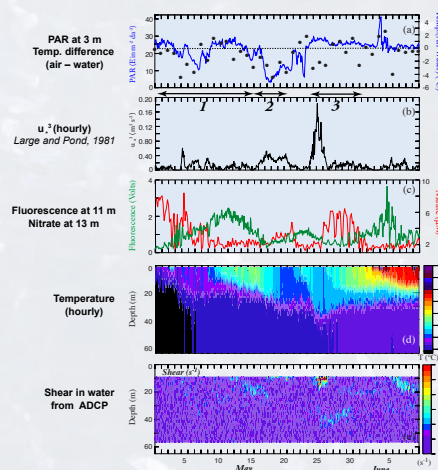
Physics, Plankton and Whales



Location of tagged right whale. Colors differentiate months (July-September). Courtesy of A. Zerbini

A year-long record from M2 integrates measures of large whale occurrence, zooplankton and phytoplankton biomass, and physics. Whale presence was estimated from passive acoustic recorder and zooplankton biovolume from a TAPS-8 multi-frequency zooplankton acoustic profiling system. Peaks in chlorophyll were associated with late-spring stratification, fall mixing, and late-winter ice formation. The relatively high biomass of zooplankton preceding the phytoplankton bloom was most likely due to overwintering. Overall, most whale sounds were detected in late summer and fall as copepod and euphausiid biomass declined. If the number of whale calls detected is used as a proxy for abundance, the strong seasonal signal of fin whales, each of which can consume up to 700-1000 kg euphausiid/day, emphasizes the need to include these predators in ecosystem models.

Physics and Primary Production



Events defined in panel b:

1. Spring phytoplankton bloom
2. Weak winds and convective mixing, small increase in nitrate and weak bloom
3. Storm increased nutrients, resulting in phytoplankton bloom and drawdown of nitrate

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